ECO-DRAINAGE DESIGN WITH BIOSWALES AND TRASH CAPTURE FOR SUSTAINABLE FLOOD MITIGATION IN INNER CRUSHER BARANGAY BIGTE, NORZAGARAY, BULACAN

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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Civil Engineering
Major in Construction Engineering and Management

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RECOMMENDATION

This is to certify that this research, titled "ECO-DRAINAGE DESIGN WITH BIOSWALES AND TRASH CAPTURE FOR SUSTAINABLE FLOOD MITIGATION IN INNER CRUSHER BARANGAY BIGTE, NORZAGARAY, BULACAN", prepared and submitted by Merry Maxine E. Feliciano, Mark Vincent Hayagan, John Kenneth O. Cano, and Ana Marie Congayao in partial fulfillment of the requirements for the degree Bachelor of Science in Civil Engineering, is hereby recommended for Pre-oral Defense.

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We hereby certify that this thesis is our own work and that to the best of our knowledge and belief, it contains no material previously written or published by another person or organization nor any material which has been accepted for award of any other degree or diploma from a university or institution of higher learning, except where due acknowledgement is made thereof.

Furthermore, we declare that the intellectual content of this thesis is the product of our work although we have received assistance from others on the manner of organization, presentation, language, and style.

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CHAPTER 1

Problem and Its Background

This chapter presents the introduction of the research study, including the statement of the problem. It discusses the independent and dependent variables, as well as the scope and limitations of the study. Furthermore, it outlines the objectives of the research and provides an overview of the expected outcomes.

Introduction

This chapter presents the introduction of the research study, including the statement of the problem. It discusses the independent and dependent variables, as well as the scope and limitations of the study. Furthermore, it outlines the objectives of the research and provides an overview of the expected outcomes.

The incident of rising floods is now more evident in different communities, specifically barangays or areas in the Philippines. Some issues that cause flooding in these areas incorporate the disposal drainage system which is used for water waste coming from household. Cruz, E. C. (2010). Hydraulic computation for flood routing of a modular urban stormwater drainage system. Philippine Engineering Journal, 28(2). The usual cause of floods in different areas is because of no proper drainage system design being determine in sag area. "Sag areas" which are the low-

lying areas, are easily flooded because the water flows into the sag area are not design properly, hence they are the first to accumulate water when it rains significantly. The growing rubbish which blocked the water ways channel, is another cause of floods, which diffuse the responsibility upon the City of Manila which are traditionally like to blame garbage and clogged drainage and stream (Lagmay et al. 2017).

In some areas of the Philippines, well-designed drainage systems have mitigated risk of flooding to both the environment and the people. One design type that reduces the risk of flooding is the environmentally friendly drainage system. According to Zhang, Ge, Dahlgren, Xiao, and McPherson (2017), bioswales are effective in urban areas to reduce the amount of surface runoff and improve water quality. Bioswales mitigate flood risk by absorbing, restricting, and slowing down excess water entering the channel before it is too late for the drainage system to manage.

Another common issue is trash accumulation blocking streams and drainage channels. In fact, trash clogged streams and drainage systems have long been blamed for flooding incidents that impact the City of Manila (Lagmay et al., 2017). The report details that since 2020, 125 floating trash traps across Bataan, Bulacan, and Pampanga have kept 124 plus tons of solid waste out of the environment and highlighted the increased effect trash capture has had in reducing trash in drainage. Can you imagine how much trash would have otherwise been left in the neighborhood ruining the local economy and surrounding areas?

Community gaged waste management reduction helps lessen the risk of flooding primarily because of garbage mistakenly filling drainage systems (Arifin et al., 2025). One other method of collecting trash thereby minimizing risk to the environment and people if left unnoticed is the trash trap.

Flooding is now a major topic of discussion because it threatens both human safety and the economy. Having a Sustainable Drainage System Design (SuDS) that can help our community reduce the risk of water rising from water channels, reduce trash, and improve the environment is essential to boosting our economy.

Theoretical Framework

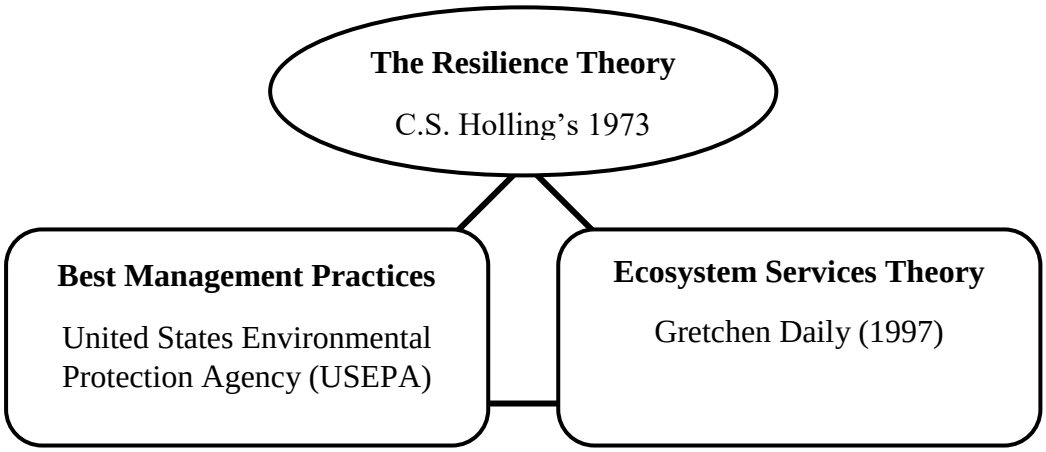

Figure 1. *Theoretical Framework*

This study is anchored on three key theories that explain the effectiveness of eco-drainage design with bioswales and trash capture systems in managing urban flooding. The Resilience Theory (Holling, 1973) highlights the system's ability to adapt to disturbances while maintaining function—bioswales and trash capture enhance drainage resilience by reducing runoff and preventing blockages. The Best Management Practices (BMP) Theory emphasizes managing stormwater at its source through natural filtration and waste interception. Lastly, the Ecosystem Services Theory underscores the ecological benefits of bioswales, such as water filtration and pollution control, complemented by trash capture systems that manage human-generated waste. Together, these theories support a sustainable and resilient approach to urban flood management.

Conceptual Framework

The figure 1.2 uses input-process-output (IPO) model, or may input-process-output pattern and was establish to describe the structure of information gathering process of the study.

INPUT	PROCESS	OUTPUT
1. What is the Demographic profile of the respondents in terms of: - Name - Gender - Length of residency **2. How do the existing issues or problems affect the livelihood of the residents in Inner Crusher Barangay Bigte, Norzagaray, Bulacan in terms of:** 2.1 Natural flow of water from its proper source. 2.2 The safety of residents and vehicles caused by rising water runoff from drainage systems. 2.3 Environmental issues related to affected plantations and cleanliness.	**1. Surveying** **2. Design and Analysis of eco-drainage design.** **3. Statistical Treatment** **4. Informal interview with questionnaire** **5. Cost Analysis for the implementation**	**1. Documented effects of existing problems on the residents' livelihood** **2. Recommended Eco-drainage Design (Bioswales + Trash Capture System)** 2.1 Proposed layout of the new drainage system. **3. There is a significant relationship between eco-drainage design and managing storm water run-off.** **4. Statistical Treatment Results** **5. Prototype or Model** 5.1 Digital prototype of the proposed drainage system

3. How can the installation of bioswales and trash capture systems help the residents in the said barangay? **4. Is it necessary to install bioswales and trash capture systems in Inner Crusher Barangay Bigte, Norzagaray, Bulacan to mitigate stormwater runoff?**		**6. Cost / Benefits Analysis** 6.1 Project feasibility 6.2 Cost-Benefit Ratio

Figure 1.2. *Conceptual Framework*

Statement of The Problem

The general problem of this study is to demonstrate the effectiveness of bioswales and trash capture systems in mitigating flooding that occurs in Inner Crusher Barangay Bigte, Norzagaray, Bulacan. the researchers seek to find answer to the following questions:

1. What is the demographic profile of the respondents in terms of:
    1.1 Name
    1.2 Gender
    1.3 Length of residency
2. How do the existing issues or problems affect the livelihood of the residents in Inner Crusher Barangay Bigte, Norzagaray, Bulacan in terms of:
    2.1 Natural flow of water from its proper source.
    2.2 The safety of residents and vehicles caused by rising water runoff from drainage systems.
    2.3 Environmental issues related to affected plantations and cleanliness.
3. How can the installation of bioswales and trash capture be assessed in terms of:
    3.1 Sustainability
    3.2 Cost-effectiveness
    3.3 Lifespan

4. How effective does the installation of bioswales and trash capture be measured to mitigate storm drainage runoff in terms of:
    4.1 Bioswales
        4.1.1. Vegetation and soil
        4.1.2. Volume of runoff
    4.2 Trash capture
        4.2.1 Cleaning blockage
        4.2.2 Rewatering

Objectives of The Study

The primary objective of this study is to address the flood-prone areas in Inner Crusher Barangay Bigte, Norzagaray, Bulacan by providing solutions that can help residents resolve common flooding problems and serve as a reference for future drainage system designs. Specifically, this study aims to:

1. To determine the applicability of the proposed design in areas experiencing frequent water runoff and overflow.
2. To identify the main reasons why this design should be implemented in the said barangay.
3. To address existing issues and develop possible solutions that will benefit local residents in the long run. The study also involves conducting surveys and applying the gathered insights to the proposed

design while ensuring that basic needs are met and no disturbances are caused to others.

4. To focus the design on serving the local residents of the barangay, including the learners from the nearby daycare center, ensuring their safety and preventing possible accidents related to poor drainage.

Hypothesis

Null Hypothesis (Ho): There is no significant relationship between eco-drainage design, bioswales, and trash capture and sustainable flood mitigation.

Alternative Hypothesis (Ha): There is a significant relationship between eco-drainage design, bioswales, and trash capture and sustainable flood mitigation.

Significance of The Study

The importance of this study lies in the problem of flooding continually occurring in Inner Crusher, Barangay Bigte, Bulacan, which affects the daily lives of local residents as well as their properties and local developments. The study presented an environmentally sensitive drainage system including bioswales and trash capture systems, with a focus on providing solution for reducing the potential

for floods. The potential to benefit the residents comes from an increased sense of safety, decreased risk of property damage, providing benefit to local government units as they can use the findings towards a more sustainable and inexpensive way in managing floods, and for future researchers it can be used as a reference when implementing a sustainable drainage solution in other flooding locations. Furthermore, the study demonstrated opportunities for increasing environmentally responsible awareness through the viewpoint of integrated natural and engineered systems within the urban systems context. This study is deemed significant to the following.

1. STUDENTS. This study's findings are highly relevant to future students in the same program, as the topics align with their curriculum. Specifically, the research provides a practical foundation for understanding and properly designing drainage systems, a core skill within the engineering field.

2. ENGINEERS. The study's conclusions offer practical information for engineers, assisting them in designing effective drainage systems and providing the analytical framework necessary to evaluate potential design challenges. Crucially, the research highlights the significant advantages of implementing bioswales and trash capture as flood mitigation tools.

3. TEACHER/INSTRUCTOR/MENTOR/PROFFESOR. This research offers valuable, topic-specific information that engineering educators can integrate into their lessons, enabling students to more effectively grasp the concepts and practical applications of bioswales and trash capture systems.

4. BARANGAY AND LOCAL RESIDENCE. This research holds great significance for the local residents and the barangay because its core goal is to enhance the safety, cleanliness, and overall livability of the community. The barangay is crucial, serving as the main location for implementing and testing the proposed solutions. The study's findings will directly benefit them by offering information and practical solutions to improve the drainage system, reduce stormwater runoff, and foster environmental sustainability. Furthermore, implementing bioswales and trash capture will not only mitigate flooding but also raise awareness among residents about the damaging effects of poor waste and water management practices.

5. FUTURE RESEARCHERS. This study will be a valuable reference for future researchers whose work involves similar discussions or topics relevant to the context of this study.

Scope and Limitation

Scope

This study focuses on designing a sustainable drainage system aimed at mitigating and reducing water runoff in the specified barangay. The process involves a thorough evaluation of the existing drainage infrastructure, analysis of regional weather patterns, and review of green design options.

Limitations

The research findings are site-specific and applicable only to areas with similar problems and conditions. The study faces several limitations, including the short timeframe and budget, difficulties in obtaining historical and current data, and challenges related to reconstructing site history, which may restrict a more profound analysis. Despite these constraints, the goal is to provide timely and tailored solutions for the local community.

DEFINITION OF TERMS

Some of the words that might be incomprehensible to the readers are defined by the researchers conjoin with the definition in the dictionary.

Bioswales a vegetated, linear ditch designed to collect, treat, and infiltrate stormwater runoff, replacing traditional concrete gutters and acting as a natural filter for pollutants.

Blue-Green Infrastructure a sustainable approach to urban water management that integrates natural systems and green spaces with engineered elements, functioning as sponge to absorb, store, and purify rainwater while mitigating flood risk.

Green Infrastructure is a strategic network of green and blue (water) spaces and features that are planned and managed to deliver multiple environmental, economic, and social benefits, such as improved water quality, reduced flooding, increased biodiversity, and better air quality.

Infiltration is the process by which water on the ground surface enters the soil. It is commonly used in both hydrology and soil sciences. The infiltration capacity is defined as the maximum rate of infiltration.

Sustainable Drainage System (SuDS) mimics the natural water cycle to manage surface water runoff at or near its source, integrating water quantity, quality, amenity, and biodiversity.

Trash Capture it is a device designed to prevent the passage of solid waste into waterways, hence enhancing the overall water quality.

Water Runoff the movement of water across the Earth's surface, usually downhill, when the ground cannot absorb any more precipitation or meltwater.

CHAPTER 2

Review of Related Literature and Studies

This chapter will contain information done by the proponents in relation to the topic regarding the importance of first-rate training to college students' preparedness for future employment. It includes differences and similarities with regard to trainings of school colleges and universities. It covers ideas related to student's preparedness, trainings and student's outcome.

Foreign Literature

The increasing issue of rising water runoff in the Philippines is further aggravated by poorly constructed and inadequately designed drainage systems. According to Zhang, Li, and Chen (2025), drainage system design significantly influences environmental water quality and flood responses, highlighting the importance of adopting effective drainage strategies. Improperly functioning drainage may cause significant losses. Proper design also requires considering essential features such as appropriate slopes and reinforcement of high-flow areas. Proper design of drainage can help reduce the negative impacts on human lives due to rising water runoff.

According to Escobar Carías, Johnston, Knott, and Sweeney (2022), flood disasters significantly worsen both physical and mental health outcomes among the

urban poor, with depressive symptoms persisting longer than physical illnesses. Some countries have implemented solutions such as bioswales and trash capture to address this environmental issue. The use of bioswales as a component of eco-drainage planning is now a major theme in sustainable stormwater management studies.

Şen and 5at (2024) emphasized that bioswales are essential elements of nature-based solutions (NBS), where they deliver ecological technological, and socio-economic advantages if well designed and well maintained. Their review notes the significance of materials, orientation, and site-specific factors in maintaining long-term urban resilience.

Kinoshita and Ozaki (2024) illustrated using GIS-based modeling that bioswales, as well as green roofs, help in minimizing runoff coefficients and alleviating urban flooding. Nevertheless, their usefulness is somewhat restricted when built in downstream sewer sections, indicating that optimal location within the drainage network is essential for maximizing their potential. Another solution is the use of trash capture to reduce channel clogging.

According to Caltrans (2024), full-capture devices installed in storm drain inlets were effective in preventing storm drain blockage and local flooding, while also keeping trash out of waterways.

LOCAL LITERATURE

As the issue arises large numbers of trash and polluted water greatly affect economic biodiversity. As variety of garbage contains contaminants that could damage our natural environment and our biodiversity causing loss of life however bioswales and trash capture have help minimize the negative effect of this challenges. In the Filipino setting, the implementation of nature-based solutions is beginning to emerge. Estrella et al. (2021) argued that the Philippines has large-scale stormwater management challenges owing to urbanization and scarcity of drainage infrastructure. They mentioned that green infrastructure strategies like bioswales, rain gardens, and permeable pavements are being considered to decrease runoff and increase water quality, albeit functional implementation is small.

In Metro Manila, Perez et al. (2020) assessed low-impact development (LID) measures and hypothesized that bioswales can effectively minimize peak runoff and enhance infiltration in densely urbanized areas. Still, they highlighted that land use conflicts and maintenance are hindrances to extensive implementation. In the Philippine context, various studies have checked the efficacy of garbage capture devices and the effectiveness of municipal solid waste management.

A study in Odiongan, Romblon (2023) came up with and implemented floating garbage traps created from recycled plastic bottles and reported that the

devices were successful in gathering an average of 1.8–2.09 kilograms of wastes every day, with plastics constituting most of the collected debris. However, without proper management and support from the government, community, and leaders, green infrastructure such as bioswales and trash capture will not function effectively. Their efficacy can only be ensured if implemented alongside appropriate interventions and active participation from the people, which in turn can positively impact the economy. This research proved the practicality of low-cost and community-based technologies in responding to litter leakage in waterways.

Likewise, Borongan et al. (2022) investigated the challenges and possibilities of mitigating marine plastic pollution in Manila, highlighting that although floating booms and traps are substantial in terms of intercepting floating litter, their functionality is usually restricted by operational issues like heavy waste loads and weak local government capacity for recurrent maintenance. In the Philippines, several researches have been done on Low Impact Development (LID) and ecodrainage system such as bioswales implementation. Cruz (2020) mentioned that the country's LID adoption is slow because of budget limitations and insufficient technical capacity for the local government units. At the same time, Santos and Dela Peña (2021) analyzed pilot bioswale initiatives in Metro Manila and determined that although such projects resulted in beneficial impacts on runoff mitigation and water quality improvement, they were unable to mitigate largescale flooding.

Also, Mendoza (2023) noted that there was a need to evaluate the climate resilience of LID practices in tropical settings and stressed the necessity for additional local case studies to enhance their use and efficiency. Additionally, the Department of Public Works and Highways (DPWH, 2022) initiated pilot projects incorporating bioswales within road networks as part of sustainable drainage system efforts. These illustrate increased awareness of eco-drainage systems in the local context, although extensive application is in its infancy.

FOREIGN STUDIES

The study of bioswales for flood mitigation and environmental enhancement has greatly impacted many countries, some of which have already adopted green infrastructure such as swales. A bioswale is a linear, vegetated slope designed to capture, filter, and infiltrate stormwater runoff from urban areas. The implementation of bioswales in various countries has proven that they can serve as an effective green alternative for stormwater management, mitigating floods, and improving water quality (Patil & Patil, 2023).

Some areas, such as sponge cities in China, have adopted the use of swales, and this approach has proven effective. In the study conducted by Xu et al. (2020) entitle 'Sponge City Practice in China: A Review of Construction, Assessment, Operational and Maintenance" that reviewed the entire process of Sponge City Programs (SCP) in China, ranging from planning and design to construction,

evaluation, and long-term operation. Through content analysis, the research evaluated the accomplishments and failures of pilot projects. Results showed that sponge cities are effective in flood mitigation, stormwater management, and water quality improvement, with wide application of green infrastructure including green roofs, permeable pavements, rain gardens, and wetlands. Still, funding, management, and participation of the public remain challenging as well as the requirement for long-term monitoring and uniform assessment standards. Improving waterways by using trash capture systems is an effective way to reduce channel blockage.

These systems, also known as trash traps, are vital tools for preventing litter from entering rivers, lakes, and oceans, ensuring drainage systems function smoothly. Items like plastic bags, cigarette butts, and food wrappers, are often collected which significantly reduce the amount of debris that can harm biodiversity and ecosystems, Asadi (2023).

In the study conducted by Liu et al. (2021) highlight that green infrastructure (GI) is an affordable means to solve social and environmental problems through ecosystem services. Their research in Shenyang (1995–2015) demonstrates drastic changes in GI composition, configuration, and connectivity. By applying pinch point identification and barrier detection, they recommended conservation measures like safeguarding prominent structures, eliminating barriers, and implementing land-use-specific interventions. These interventions will enhance urban resilience and inform policy and planning for megacities.

In the study conducted by Almaaitah et al. (2021) performed a state-of-the-art overview of Blue-Green Infrastructure (BGI) as a means of mitigating the effects of climate change, including rising air temperatures and floods. In their review, they critically assessed 32 published papers, the majority of which were published after 2015, with issues such as urban heat island mitigation and stormwater management. Findings indicated that BGI is viable for urban runoff management and heat mitigation, with a stronger focus within literature on stormwater management. Studies of blue and blue-green roofs tended to examine a single function, either thermal or hydrologic, without considering the multiple benefits. Most studies were done on large urban levels based on computer simulation and sensor monitoring.

LOCAL STUDIES

Regarding the issue of water runoff and its relation to Sustainable Urban Drainage Systems (SuDS), many considerations are required in the design and planning of drainage systems, such as site location and local environmental characteristics. This highlights the importance of having complete and reliable data to ensure proper design and effective implementation. This study conducted by Nacpil et al. (2023) Flood Mitigation Management using PESTLE-based Assessment Tool for SUDS Adaptation. The research targets the assessment of locations' suitability for the implementation of Sustainable Urban Drainage

Systems (SUDS) as a substitute for traditional urban drainage in flood management control. The authors created an assessment framework based on the PESTLE methodology (Political, Economic, Social, Technological, Legal, and Environmental elements) to examine external factors impacting SUDS incorporation. The instrument was used in Bulaon Resettlement barangay to determine adaptation challenges. Surveys uncovered serious data gaps in the location that limit successful SUDS adaptation. The research reiterates the importance of current and complete data that will improve chances of successful implementation. The PESTLE-based assessment instrument can enhance flood mitigation management through the ability to guide decision-makers and stakeholders in establishing priority areas and optimizing strategy for sustainable SUDS adaptation. Sustainable Urban Drainage Systems (SuDS) play a significant role as an affordable solution for flood mitigation, taking into account factors such as site characteristics, environmental and biodiversity impacts, and economic effectiveness.

In the study conducted by Garbanzo (2022). Evaluation of Low Impact Development (LID) Structures in Flood Control and Cost-Effectiveness in Cavite, Philippines. The research assesses the technical efficiency and economic viability of different LID schemes in resolving urban flooding as well as groundwater issues in a Cavite residential park. Through the Stormwater Management Model (SWMM) and life cycle cost analysis, the research examined LID types (Bioretention, Infiltration Trench, Permeable Pavement) for various rainfall percentiles and estimated costs. A cost-effectiveness (C/E) analysis was done

comparing decentralized, centralized, and integrated models. The findings decentralized and integrated decentralized models were better, recording up to 38.67% reduction in flow, 29.73% reduction in peak flow, 100% volume reduction, and 52.33% runoff reduction, especially in the BR+IT+PP scenario. These performances would save pipe sizes by 0.1–16% and infiltration by up to 1,113%. Economically, LIDs recorded 29–94% capital cost savings and 20–96% lifecycle cost savings compared to conventional drainage.

In the study conducted by Frias, R.A.G. (2021). Modelling the Applicability of Low Impact Development (LID) Technologies in a University Campus in the Philippines Using SWMM, a study aimed to evaluate the effectiveness and applicability of different LID technologies in reducing stormwater runoff, enhancing infiltration, and addressing urban stormwater in DLSU–Laguna. The research created 810 scenarios with three defined sub-catchments, five intensities of rainfall (60th–95th percentile), eight LID controls (bioretention cell, infiltration trench, rain garden, green roof, permeable pavement, rain barrel, rooftop disconnection, vegetative swale), and a no-LID baseline. Data were collected, processed, modeled through SWMM, and evaluated through green-gray ratio (GG ratio) as performance indicator. Following findings indicated 12–80% reduction of runoff and 0–55% increase in infiltration when LID is implemented. Rainfall intensity and percent imperviousness were positively related to runoff and inversely related to infiltration. In the LID controls, infiltration trench worked best to reduce runoff, infiltration, and GG ratio efficiency. The optimal GG ratio was found to be 11:5, after which more green

space brought little return. LID technologies, especially infiltration trenches, work well for adaptive stormwater management in the country's developing regions. In the context of bioswales, the integration of grasses is a critical consideration, as they improve infiltration capacity and enhance the efficiency of pollutant removal from stormwater runoff.

In the study conducted by Buenvenida et al. (2020-2021) entitled "Pollutant uptake and runoff storage testing of bioswale with potential vegetation". The focused of this research aimed to determine the efficacy of bioswales, especially vegetated ones, in eliminating pollutants from stormwater runoff from impervious surfaces like parking lots. Three bioswale set-ups were tried: Non-vegetated (control), lemongrass cover, vetiver grass cover. The efficacy of pollutant removal was determined for five pollutants (ammonia, nitrate, phosphate, copper, and iron). The retention time and infiltration rates were also analyzed. The findings all configurations lowered pollutant concentrations, with the highest pollutant removal of 99.3% iron (lemongrass configuration). The lowest was 34.2% removal of ammonia (control configuration). Statistical analysis showed significant difference solely for ammonia removal ($p \leq 0.05$). Vetiver grass had the highest retention time (19 minutes) and infiltration rate (0.060 cm/min), which maximized pollutant removal capability. Generally, vetiver grass bioswales had the highest pollutant removal compared to lemongrass and control configurations. Another approach that aids in waste removal from drainage channels is trash capture, which in other areas has significantly improved the collection of large amounts of garbage and helped prevent drainage overflow.

According to Dela Cruz, Manalili, and Santos (2024), a study assessed the feasibility of installing a trash trap in Sto. Tomas Creek, Pampanga using the PESTLE framework. With an average score of 3.57, the results indicate sufficient feasibility supported by political, legal, and environmental factors, though economic and technological readiness still require improvement. Overall, the project is achievable if supported by stronger funding, enhanced technical capacity, and sustained community involvement.

Synthesis of Related Literature and Study

The above collected foreign and local literature and studies provides information that bioswales and trash capture have greatly impacted some countries its effectiveness among countries that adopted it. Study has shown that ways of other countries in mitigating flood is through the application of bioswales and trash-capture.

The Collections of studies and literature are related in the importance of creating sustainable urban drainage design for flood mitigation. This provides information that bioswales help reduce water runoff, while trash capture reduces waste to prevent blockages in canals that cause flooding.

CHAPTER 3

Research Methodology

This chapter focuses on the research methodology, detailing the procedures to be employed. This includes the research design, sampling (number of respondents), statistical treatment, instruments used for data gathering, and the specific surveys. These outlined methods will determine the feasibility and potential outcomes of the study, enabling the researchers to explain the findings comprehensively and gain additional knowledge.

Research Design

This chapter focuses on the research methodology, detailing the procedures to be employed. This includes the research design, sampling (number of respondents), statistical treatment, instruments used for data gathering, and the specific surveys. These outlined methods will determine the feasibility and potential outcomes of the study, enabling the researchers to explain the findings comprehensively and gain additional knowledge. The conclusion of this chapter focuses on the procedures of the data gathering used in the area.

This study employs a mixed-methods approach, combining quantitative analysis with design-based modeling to evaluate the effectiveness, safety, and cost

efficiency of the proposed bioswale and trash capture drainage system at Inner Crusher Barangay Bigte, Norzagaray, Bulacan.

The quantitative approach is vital to this study as it allows for a systematic and objective assessment of the eco-drainage design with bioswales and trash capture systems. By using measurable data such as flow rate, infiltration, and water quality, the study evaluates the system's effectiveness in reducing runoff and mitigating floods. This data-driven approach ensures reliable and unbiased results that can guide future urban drainage planning and policy decisions (Escuder-Bueno et al., 2012).

Furthermore, numerous quantitative studies in urban flooding and infrastructure decision-making contexts (Escuder-Bueno et al., 2012; Wang et al., 2023) demonstrate that using numerical data and statistical methods promotes objective and replicable findings while minimizing bias in planning and policy development. This approach enables design planners and engineers to make well-informed, evidence-based decisions that enhance the effectiveness and sustainability of infrastructure improvements.

Sample and Population

The target population of this study includes approximately 20 households residing in flood-prone areas of Barangay Bigte Inner Crusher. These households

vary in family size, economic background, and experiences related to flooding in the community.

From this population, a total of 60 individual respondents will be chosen using purposive sampling. Respondents will be selected based on their availability and willingness to participate, ensuring that different age groups and personal experiences are represented. This approach allows the study to gather meaningful insights and diverse perspectives while keeping the sample size manageable for effective analysis.

Sample Size:

- Total Population: 20 households
- Sample Size: 60 respondents

Research Instrument

This study used a structured questionnaire as the main research tool to collect data on the awareness, perspective, and practices of community members towards the proposed eco-drainage design with bioswales and trash-capture system for sustainable flood mitigation in inner crusher barangay Bigte, Norzagaray, Bulacan. The questionnaire contained fourteen (20) items with 3 sections. The first section is the respondent's demographic profile, this part gathered background data from the respondents such as their name, age, sex, length of stay, and house location from the drainage canal or flood-prone areas. These data were utilized to

ascertain the correspondence between the demographic characteristics of the respondents and the flooding and drainage experience. The second section is examining the surroundings, flooding, and drainage experience of the respondents. This part comprised seven (7) statements that aimed to gauge the observations and experiences of the respondents on the state of roads, instances of flooding, drainage capacity, and maintenance concerns in Barangay Inner Crusher Bigte. Respondents answered each statement based on a five-point Likert scale, which varied from Strongly Disagree (1) to Strongly Agree (5). The questions addressed topics including road conditions, frequency of flooding, blockage in drainage, maintenance of the system, and perceived success of a new eco-drainage system using bioswales and trash-capture systems. The third section is the opinion-based questions, this part involved open-ended questions to obtain quantitative responses from the participants. Respondents were questioned on their awareness and perception of bioswales and trash-capture systems, and they were also asked for their recommendations to enhance the drainage systems in their area. This permitted respondents to freely comment and offer advice on how to improve flood prevention and drainage administration in Barangay Inner Crusher Bigte. In totality, the research tool was structured to elicit quantitative information to aid in the assessment and design of an eco-friendly eco-drainage system that utilizes bioswales and trash-capture technology for efficient flood control and waste management within the area.

Data Gathering

The researchers used a questionnaire to gather the necessary information for this study. Before distribution, the questionnaire was reviewed and approved by research experts and panelists to ensure its validity and reliability. It was then administered to the respondents through survey forms, allowing them to answer based on their personal experiences. The researchers assured all participants that their responses would remain confidential and would be used solely for research purposes. Data collection was conducted over a period of seven (7) days, after which the gathered responses were tallied, organized, and analyzed using appropriate statistical tools.

Statistical Treatment

The gathered data was organized and properly arranged, tabulated, and illustrated in tables and charts. Statistics is a type of analysis that involves using various statistical tools to analyze and interpret the outcomes of data presented in a study. The researchers utilized the statistical tools listed below, as they were deemed appropriate and suitable for the nature of this research.

1. **Frequency and Percentage**

$$\boldsymbol{P = \frac{F}{N}(100)}$$

P = Percentage

F = Frequency

N = Total number of respondents

100 = Constant multiplier

Weighted mean

$$\boldsymbol{W = \frac{\sum F \times x}{N}}$$

2. Rainfall-Runoff

$$\boldsymbol{Q = CIA}$$

Q **=** peak run-off (m^3/s)

C **=** runoff coefficient

I **=** rainfall intensity (mm/hr)

A **=** drainage area (m^2)

3. Bioswales Storage Volume

$$\boldsymbol{V = \frac{Q \times t}{3600}}$$

V = volume of runoff (m^3)

Q = runoff rate (m^3/s)

t = duration of storm (seconds)

4. Infiltration Rate

Darcy's Law

$$Q = K \times A \times \frac{h}{L}$$

Q = discharge rate (m^3/s)

K = hydraulic conductivity (m/s)

A = cross-sectional area (m^2)

h/L = hydraulic gradient

5. Pollutant Removal Efficiency

$$Removal\ Efficiency(\%) = \frac{C_i - C_o}{C_i} \times 100$$

Ci = influent concentration (before bioswales)

Co = effluent concentration (after bioswales)

6. Cost-Benefit Ratio (CBR)

$$CBR = \frac{Total\ Benefits}{Total\ Costs}$$